

PATENT COOPERATION TREATY

From the:
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

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To:

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PCT

NOTIFICATION OF TRANSMITTAL OF
INTERNATIONAL PRELIMINARY
REPORT ON PATENTABILITY
(Chapter II of the Patent Cooperation Treaty)

(PCT Rule 71.1)

Date of mailing
(day/month/year) **1 AUG 2005**

Applicant's or agent's file reference
NANY/20402181/KC

IMPORTANT NOTIFICATION

International application No.
PCT/SG2004/000371

International filing date (day/month/year)
17 November 2004

Priority date (day/month/year)
18 November 2003

Applicant

NANYANG TECHNOLOGICAL UNIVERSITY et al

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary report on patentability and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translations to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary report on patentability. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the *PCT Applicant's Guide*.

The applicant's attention is drawn to Article 33(5), which provides that the criteria of novelty, inventive step and industrial applicability described in Article 33(2) to (4) merely serve the purposes of international preliminary examination and that "any Contracting State may apply additional or different criteria for the purposes of deciding whether, in that State, the claimed invention is patentable or not" (see also Article 27(5)). Such additional criteria may relate, for example, to exemptions from patentability, requirements for enabling disclosure, clarity and support for the claims.

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PATENT COOPERATION TREATY
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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY
(Chapter II of the Patent Cooperation Treaty)
(PCT Article 36 and Rule 70)

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| Applicant's or agent's file reference NANY/20402181/KC | FOR FURTHER ACTION | See Form PCT/IPEA/416 |
| International application No. PCT/SG2004/000371 | International filing date (<i>day/month/year</i>) 17 November 2004 | Priority date (<i>day/month/year</i>) 18 November 2003 |
| International Patent Classification (IPC) or national classification and IPC Int. Cl. ⁷ B81B 7/00, 1/00; B01D 61/42 | | |
| Applicant NANYANG TECHNOLOGICAL UNIVERSITY et al | | |

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 3 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
 - a. ☒ (*sent to the applicant and to the International Bureau*) a total of 4 sheets, as follows:

☒ sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
 - b. ☐ (*sent to the International Bureau only*) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or table related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).
4. This report contains indications relating to the following items:

| | |
|---|---|
| <input checked="" type="checkbox"/> Box No. I | Basis of the report |
| <input type="checkbox"/> Box No. II | Priority |
| <input type="checkbox"/> Box No. III | Non-establishment of opinion with regard to novelty, inventive step and industrial applicability |
| <input type="checkbox"/> Box No. IV | Lack of unity of invention |
| <input checked="" type="checkbox"/> Box No. V | Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement |
| <input type="checkbox"/> Box No. VI | Certain documents cited |
| <input type="checkbox"/> Box No. VII | Certain defects in the international application |
| <input type="checkbox"/> Box No. VIII | Certain observations on the international application |

| | |
|--|---|
| Date of submission of the demand 13 May 2005 | Date of completion of the report 25 July 2005 |
| Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaaustralia.gov.au Facsimile No. (02) 6285 3929 | Authorized Officer JULIA HU Telephone No. (02) 6283 2754 |

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.
- ☐ This report is based on translations from the original language into the following language which is the language of a translation furnished for the purposes of:
- ☐ international search (under Rules 12.3 and 23.1 (b))
 - ☐ publication of the international application (under Rule 12.4)
 - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)
2. With regard to the **elements** of the international application, this report is based on (*replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report*):
- ☐ the international application as originally filed/furnished
- ☒ the description:
- pages **1-12** as originally filed/furnished
- pages* received by this Authority on with the letter of
- pages* received by this Authority on with the letter of
- ☒ the claims:
- pages as originally filed/furnished
- pages* **17-20** as amended (together with any statement) under Article 19
- pages* received by this Authority on with the letter of
- pages* received by this Authority on with the letter of
- ☒ the drawings:
- pages **1/5-5/5** as originally filed/furnished
- pages* received by this Authority on with the letter of
- pages* received by this Authority on with the letter of
- ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing.
3. ☒ The amendments have resulted in the cancellation of:
- ☐ the description, pages
 - ☒ the claims, pages **13-16**
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
 - ☐ any table(s) related to the sequence listing (*specify*):
4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
- ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
 - ☐ any table(s) related to the sequence listing (*specify*):

* If item 4 applies, some or all of those sheets may be marked "superseded."

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**1. Statement**

| | | |
|-------------------------------|-------------|-----|
| Novelty (N) | Claims 1-33 | YES |
| | Claims | NO |
| Inventive step (IS) | Claims 1-33 | YES |
| | Claims | NO |
| Industrial applicability (IA) | Claims 1-33 | YES |
| | Claims | NO |

2. Citations and explanations (Rule 70.7)**NOVELTY (N) AND INVENTIVE STEP (IS) claims 1-33**

The invention of the claims is a method of actuating and an actuator operated by electroosmotic force. No individual citation or obvious combination of citations disclose or fairly suggest all of the features of such an actuator.

The closest art of US 6537437 discloses a similar device (Fig. 6). However, it has a closed chamber 72 with a movable/deformable membrane 74 connecting an actuator arm 76 and a pump 70, as opposed to an open-ended tube with an actuator/piston in direct fluid communication with the liquid in the tube (wherein an electrical field is applied along a lengthwise axis across the tube) as defined in the present claims. The latter device offers a simpler and more compact structure and does not appear to be obvious from the teaching of the prior art. Therefore, the invention as defined in the present claims is considered to be novel and inventive.

AMENDED CLAIMS

**[Received by the International Bureau on 31 March 2005 (31.03.05):
original claims 4 and 19 have been cancelled. Original claims 1-3, 5-18, 20-35 have been
replaced by amended claims 1-33 (4 pages)]**

1. A method of actuating, comprising:
 - filling at least a portion of a tube with a liquid containing electrolytes, the tube having an open end and an inner surface that is electrically chargeable when in contact with the liquid;
 - positioning an object in fluid communication with the liquid in the tube through the open end; and
 - applying an electrical field along a lengthwise axis across the tube at said portion for producing a pressure in the liquid;
 - wherein the pressure in the liquid exerts a force on the object so as to actuate the object.
2. The method of claim 1, wherein the inner surface is electrically chargeable due to electrochemical phenomena.
3. The method of claim 1 or claim 2, wherein the tube is selected from the group comprising: capillary tube and micro-capillary tube.
4. The method of any one of claims 1 to 3, further including an additional plurality of tubes each at least partially filled with a liquid containing electrolytes in fluid communication with the object.
5. The method of claim 4, wherein the plurality of tubes are formed in a porous material.
6. The method of claim 5, wherein the porous material is made from at least one material selected from the group consisting of: silica, and ceramics.
7. The method of claim 6, wherein the porous material has at least one material property selected from the group consisting of: electrically non-conductive, porous structure, micro capillaries, small particles, and hydrophilic.

8. The method of any one of claims 1 to 7, wherein the electric field is generated from a power supply selected from the group consisting of: AC and DC.
9. The method of claim 8, wherein the DC power supply is linked to an on-off frequency controller.
10. The method of any one of claims 1 to 9, wherein the pressure in the liquid is caused by electroosmotic flow.
11. The method of claim 5, wherein a higher force on the object is generated by adopting techniques selected from the group comprising: using porous material with small pore sizes and using porous material with large cross-sectional areas.
12. The method of claim 1, wherein a higher force on the object is attained by using a lower concentration of the liquid containing electrolytes.
13. The method of claim 1, wherein a higher force on the object is attained by generating a stronger electric field.
14. The method as claimed in any one of claims 1 to 12 when as used in an actuator.
15. An actuator comprising:
 - a tube with an open end and an inner surface and at least partially filled with a liquid containing an electrolyte, the inner surface being electrically chargeable when in contact with the liquid;
 - an electric field generator for generating a field along a lengthwise axis of the tube to induce a pressure in the liquid;
 - an object in fluid communication with the liquid in the tube through the open end such that the pressure in the liquid exerts a force on the object;
 - and wherein the force on the object is able to actuate the object.

16. The actuator of claim 15, wherein the inner surface is electrically chargeable due to electrochemical phenomena.
17. The actuator of claim 15 or claim 16, wherein the tube is selected from the group consisting of: capillary tube and micro-capillary tube
18. The actuator of any one of claims 15 to 17, further including an additional plurality of tubes each at least partially filled with a liquid containing electrolytes in fluid communication with the object.
19. The actuator of claim 18, wherein the plurality of tubes are formed in a porous material.
20. The actuator of claim 19, wherein the porous material is of at least one material selected from the group consisting of: silica, and ceramics.
21. The actuator of claim 19, wherein the porous material has at least one material property selected from the group consisting of: electrically non-conductive, porous structure, micro capillaries, small particles, and hydrophilic
22. The actuator of any one of claims 15 to 21, wherein the electric field generator generates power supplies selected from the group consisting of: AC and DC.
23. The actuator of claim 22, wherein the DC power supply is linked to an on-off frequency controller.
24. The actuator of any one of claims 15 to 23, wherein the pressure in the liquid is caused by electroosmotic flow.
25. The actuator of claim 19, wherein a higher force on the object is generated by adopting techniques selected from the group consisting of: using porous material with small pore sizes, and using porous material with large cross-sectional areas.

26. The actuator of claim 15, wherein a higher force on the object is attained by using a lower concentration of the liquid containing electrolytes.
27. The actuator of claim 15, wherein a higher force on the object is attained by generating a stronger electric field.
28. The actuator of any one of claims 15 to 27, further comprising a housing defining a chamber containing the tube, and a cylinder in fluid communication with the chamber, wherein the tube is in the cylinder and the object is a piston slideably mounted in the cylinder.
29. The actuator of claim 28, wherein the piston is biased to resist a force exerted thereon from the tube.
30. The actuator of claim 29, further comprising a displacement amplifier operatively connected to the piston.
31. The actuator of claim 28, wherein the piston has silicone seals.
32. The actuator of claim any one of claims 19 to 21, or any one of claims 22 to 25 when appended to claim 19, further comprising a compensating piston to prevent a drop of pressure in the porous material.
33. The actuator of claim 28, further comprising a vent in the housing for allowing the exchange of air within the chamber.